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[0001] RANDOM ACCESS CHANNEL ACCESS AND BACKOFF MECHANISM

[0002] CROSS REFERENCE TO RELATED APPLICATION(S)

[0003] This application is a continuation of U.S. Patent Application Serial No. 09/593,879 filed June 14, 2000, which is incorporated by reference as if fully set forth.

[0004] BACKGROUND

[0005] The invention relates generally to resource allocation in a wireless code division multiple access communication system. More specifically, the invention relates to controlling user equipment access attempts for communicating over a random access channel in a wireless code division multiple access communication system.

[0006] Figure 1 depicts a wireless spread spectrum Code Division Multiple Access (CDMA) communication system 18. A base station 20 communicates with user equipments (UEs) 22_1- 22_N in its operating area. In a spread spectrum CDMA system 18, data signals are communicated between UEs 22_1- 22_N and the base station 20 over the same spread spectrum. Each data signal in the shared spectrum is spread with a unique chip code sequence. Upon reception, using a replica of the chip code sequence, a particular data signal is recovered.

[0007] Since signals are distinguished by their chip code sequences (code), separate dedicated communication channels are created using different codes. Signals from the base station 20 to the UEs 22_1- 22_N are sent on downlink channels and signals from the UEs 22_1- 22_N to the base station 20 are sent on uplink channels.

[0008] In many CDMA systems, a random access channel (RACH) is used and is capable of carrying packets of data from multiple UEs 22_1- 22_N. Each packet is distinguishable by a combination of time slot and code.

[0009] The transmission is time divided into repeating frames having time slots, such as fifteen time slots per frame. When a packet is transmitted over the RACH, it may last for multiple frames.

[0010] A typical UE RACH access attempt is as follows. Prior to communicating over the RACH, a UE 22_1 transmits an access signal to the base station 20 to access the RACH. One type of access signal uses a preamble code (preamble). The UE 22_1 repeats the preamble while incrementally increasing transmission power levels. The UE 22_1 repeats transmission of the preamble unit a response from the base station 20 is received or until a maximum number of repetitions is reached.

[0011] In response to receiving the preamble, the base station 20 determines whether the UE 22_1 may utilize the RACH. This utilization determination may be based on the availability of the RACH channel, uplink interference levels or RACH loading. If the access attempt is successful, the base station 20 transmits an acknowledgment signal (ACK) to the UE 22_1. In response to the UE 22_1 receiving the ACK, the UE sends an uplink packet over the RACH. If the RACH is not available, the base station 20 transmits a negative acknowledgment signal (NAK) to the UE 22_1. Receiving a NAK or reaching the maximum number of repetitions are unsuccessful access attempts requiring the UE 22_1 to reattempt access at a later time.

[0012] The period of time between access attempts is critical to a system's performance. If the period between access attempts is too long, the RACH will be underutilized. If the period is too short, many UEs 22_1- 22_N may repeatedly request access resulting in service interruptions.

[0013] One approach for controlling UE re-access attempts is to use a fixed backoff parameter. The UE 22_1 will reattempt access for a period of time based on the backoff parameter. The backoff parameter represents a deterministic wait period for an access reattempt. A problem with a fixed backoff parameter is that it can not be adjusted in response to the cell loading. Accordingly, during periods of light loading,

the RACH may be underutilized and in periods of high loading service interruptions may result.

[0014] Another approach is a rule based approach. The UE 22_1 analyzes its prior access attempt statistics. Based on the access statistics, the UE 22_1, applying predetermined rules, determines a backoff parameter. To illustrate, if the UE 22_1 had many unsuccessful access attempts, the period between accesses is increased. Since the UE's prior access attempts may not represent current conditions, this approach is not optimal.

[0015] Another approach is to broadcast a backoff parameter over a broadcast channel (BCH). The backoff parameter is based on the RACH's loading, uplink interference level and other factors. The backoff parameter, Ubbch, is used to derive a backoff wait period at a time n, B(n), such as by equation 1.

$$B(n) = 2^{Ubbch}$$

Equation 1

[0016] Due to delays in processing and transmitting the backoff parameter, the backoff parameter may not represent current conditions which is not optimal.

[0017] Accordingly, it is desirable to have other approaches for controlling UE access reattempts.

[0018] SUMMARY

[0019] A user equipment has a transmitter for transmitting an access attempt signal and data packets over a random access channel. The access attempt signal requests a base station to permit the user equipment access to the random access channel. A receiver receives access control signals and access control modification signals transmitted from a base station. A controller is operatively coupled to the receiver and transmitter. The controller determines a wait period based on in part the received access control signals and access control modification signals and delays

transmission of a subsequent access attempt signal for the wait period in response to an unsuccessful access attempt to the random access channel.

[0020] BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Figure 1 is an illustration of a typical wireless spread spectrum CDMA communication system.

[0022] Figure 2 is a flow chart of controlling user equipment reaccess attempts.

[0023] Figure 3 is an illustration of a simplified user equipment and base station.

[0024] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Figure 2 is a flow chart for controlling UE reaccess attempts to communicate using the RACH. The base station 20 broadcasts to all the UEs 22_1- 22_N in its operating area access parameters, 24, such as the backoff parameter, Ubbch, or the persistence parameter, Upbch. The persistence parameter represents the probability that the UE 22_1 should reattempt access within a specified time period.

[0026] The access parameters are broadcast using the base station's transmitter 38 as shown in Figure 3. Figure 3 illustrates the simplified components of a base station 20 and a UE 22_1. The base station 20 also transmits a modification signal, Pmod, to the UEs 22_1- 22_N, such as by a layer one signal, 26. Layer one, also referred to as the physical layer, signaling dramatically increases the transmission speed and update rate of the modification signal.

[0027] The modification signal is used to update the access parameters. The modification signal may simple indicate a +1 to increase an access parameter or a -1 to decrease it. Such a modification signal may be sent over the acknowledgment indicator channel (AICH). One of the AICH's signatures is reserved for use for the modification signal. The phase of the transmitted modification signal represents the value of the modification signal. Alternately, other signals associated with CDMA systems may be

used for the modification signal. If no modification signal is sent, no change is made to the access parameters. An alternate modification signal may indicate an amount of increase or decrease to an access parameter.

[0028] The value of the modification signal is determined by a controller 40 associated with the base station 20, such as a Controlling Radio Resource Controller (CRRC), and is typically based on the RACH's loading, uplink interference level, other factors or a combination of those factors. One scheme adjusts the modification signal to maintain a constant average uplink interference level. The modification signal may be sent on a periodic basis or only when the pertinent system conditions change.

[0029] The modification signal is transmitted by the base station's transmitter 38. The UE's receiver 44 receives the access parameters and the modification signals, 28. The UE's controller 46 determines the delay between access attempts using the received access parameters and modification signals, 30. The access attempts are subsequently transmitted by the UE's transmitter 42, 32.

[0030] One approach to adjusting the access period is to modify the backoff parameter, Ubbch. Equations 2 and 3 are used to determine the backoff wait period, B(n).

$$B(n) = 2^{U(n)} \qquad \text{Equation 2}$$

$$U(n) = Ubbch + Pmod \times dUb, \text{ where } Ubmin \leq U(n) \leq Ubmax \qquad \text{Equation 3}$$

[0031] The amount of backoff change, dUb, and the value of the limits, Ubmin and Ubmax, are either standardized or broadcast by the base station 20.

[0032] Another approach selectively modifies either the persistence or backoff parameter using the received modification signals. One technique for determining which parameter to modify is to distinguish the parameter modifications by a modification signal transmission time slot. To illustrate, if the AICH is used for sending the modification signal, time slot 1 indicates that the persistence parameter should be modified and time slot 4 indicates that the backoff parameter should be

modified. The UE 22_1 using its receiver would monitor the AICH for the modification signal and the controller 46 would determine the reception time slot. Additionally, the selected time slot may indicate a degree of change to the selected parameter. For instance, if the modification is sent in time slot 1, the persistence parameter is changed by dUp and if in time slot 2, the persistence parameter is changed by 2 x dUp.

[0033] One such system uses Equations 4-7. If the modification signal is used to change the persistence parameter, Equations 4 and 5 are used.

$$P(n) = 2^{Up(n)} \qquad \text{Equation 4}$$

$$Up(n) = \begin{cases} Up(n-1) + Pmod \times dUp, & \text{when Upbch is not recent} \\ Upbch, & \text{when Upbch is recent} \end{cases}$$
$$\text{, where } Upmin \leq Up(n) \leq Upmax \qquad \text{Equation 5}$$

[0034] P(n) is the probability that the UE 22_1 should attempt access in the backoff wait period. The amount of persistence change, dUp, and the value of the limits, Upmin and Upmax, are either standardized or broadcast.

[0035] If the modification signal is used to change the backoff parameter, Equations 6 and 7 are used.

$$B(n) = 2^{Ub(n)} \qquad \text{Equation 6}$$

$$Ub(n) = \begin{cases} Ub(n-1) + Pmod \times dUp, & \text{when Ubbch is not recent} \\ Ubbch, & \text{when Ubbch is recent} \end{cases}$$
$$\text{where } Ubmin \leq Ub(n) \leq Ubmax \qquad \text{Equation 7}$$

[0036] Using the current persistence and backoff parameters, the next access attempt is determined. The backoff parameter establishes the wait period and the persistence parameter establishes the probability of an access attempt in that wait period.

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